

#### US006301038B1

# (12) United States Patent

#### Fitzmaurice et al.

## (10) Patent No.: US 6,301,038 B1

## (45) **Date of Patent:** Oct. 9, 2001

#### (54) ELECTROCHROMIC SYSTEM

# (75) Inventors: **Donald Fitzmaurice**; **S. Rao Nagaraja**, both of Dublin; **Rachel Cinnscalach**, Baile Atha Cliath; **Brendan Enright**,

Cork, all of (IE)

(73) Assignee: University College Dublin, Dulin (IE)

(\*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35

U.S.C. 154(b) by 0 days.

(21) Appl. No.: **09/367,024** 

(22) PCT Filed: Feb. 6, 1998

(86) PCT No.: PCT/IE98/00008

§ 371 Date: Oct. 26, 1999 § 102(e) Date: Oct. 26, 1999

(87) PCT Pub. No.: **WO98/35267** 

PCT Pub. Date: Aug. 13, 1998

#### (30) Foreign Application Priority Data

(IE) S970082	ь. 6, 1997	Fel
G02F 1/15	Int. Cl. <sup>7</sup>	(51)
359/265; 359/270; 359/272;	U.S. Cl.	(52)
428/315.5; 428/411.1; 428/469; 428/702;		
428/704; 252/582; 252/586		
earch 359/265, 272,	Field of	(58)
359/270; 428/411.1, 457, 469, 704, 702,		
315 5: 252/582, 586		

### (56) References Cited

#### U.S. PATENT DOCUMENTS

4,343,537	*	8/1982	Guntherodt et al	350/357
5,480,629		1/1996	Thompson et al	423/584

#### FOREIGN PATENT DOCUMENTS

WO 95/30495 11/1995 (WO). WO 97/35227 9/1997 (WO).

#### OTHER PUBLICATIONS

Thompson et al. Stable photoinduced charge separation in layered viologen compounds (Nature, vol. 358, 1992, p656-658).\*

Bechinger, et al., Photoelectrochromic windows and displays, Nature, vol. 383, Oct. 17, 1996, pp. 608–610 XP 002064353.

Lampert, et al. Large-Area Chromogenics: Materials and Devices for Transmittance Control, SPIE Institutes for Advanced Optical Technologies, vol. IS 4; Sep. 22–24, 1988, Hamburg, Germany.

Hagfeldt, Anders, et al., Nanostructured TiO2 Semiconductor Electrodes Modified with Surface Attached Viologensi Applications for Displays and Smart Windows, Institut de Chimie Physique, Lausanne, Switzerland, SPIE, vol. 2531, pp. 60–69, 1995.

\* cited by examiner

Primary Examiner—Cynthia H. Kelly
Assistant Examiner—Ling Xu

(74) Attorney, Agent, or Firm—Christie, Parker & Hale, LLP

#### (57) ABSTRACT

An electrochromic system with a first electrode disposed on a transparent or translucent substrate and a second electrode, an electrolyte, an electron donor and a nanoporous-nanocrystalline film of a semiconducting metallic oxide having a redox chromophore absorbed thereto being intermediate the first and second electrodes. Such a system has a very rapid electrochromic effect.

#### 16 Claims, 9 Drawing Sheets